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Ocular Battle Injuries among U.S. Military Personnel, 2002-2011

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14. ABSTRACT

This study analyzed Joint Theater Trauma Registry (JTTR) records of 1732 U.S. military personnel sustaining 3222 ocular battle injuries (OBI) from March 2002 through December 2011 during Operation Enduring Freedom, Operation Iraqi Freedom, and Operation New Dawn. OBI incidence increased or decreased proportionally as deployed personnel numbers increased or decreased. At the individual level, explosive blasts caused 92 percent of OBI cases, resulting in multiple traumatic head injuries in 84 percent of cases. At the injury level, 50 percent of OBI were open wounds of the ocular adnexa and/or eyeball. Recommendations to increase combat ocular readiness include: allocating appropriate eye care resource and personnel levels to treat expected OBI cases whenever military personnel are deployed, evaluating and treating blast-injured OBI patients with a high index of suspicion for other occult head injuries (especially closed-eye and traumatic brain injuries), enforcing ocular personal protective equipment (PPE) use, and collecting exposure and ocular PPE use data to model the relationship between exposure, OBI severity, and ocular PPE use.

15. SUBJECT TERMS

Battle injury, blast injury, eye injury, head injury, ocular injury, Joint Theater Trauma Registry, traumatic brain injury

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<u>Preface</u>

The data in this technical report were presented in a poster, entitled "Ocular Battle Injuries among U.S. Military Personnel, 2002-2011," at the Fifth Military Vision Symposium on Ocular and Vision Injury in Boston, Massachusetts, September 2012. Michael Lo, M.S.P.H., LTC José E. Capó-Aponte, O.D., Ph.D., F.A.A.O., Dan Wise, M.Ed., Daryl Simpson, B.S.M.E., Amy Barrett, B.A., Robert Giffin, M.S.O.H., Kraig Pakulski, M.Ed., and Leonard A. Temme, Ph.D. were poster contributors. The poster is included in appendix A of this report.

The authors wish to acknowledge Dr. Nancy Molter and her team at the Joint Trauma System, U.S. Army Institute of Surgical Research (USAISR) for granting access to the data used in this study.

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Introduction

Vision loss resulting from ocular battle injuries (OBI) is particularly disabling to Warfighters because of their reliance upon acute vision to engage effectively in combat operations (Ari, 2006; National Alliance for Eye and Vision Research, 2007). The eyes are injured disproportionately more often and more severely than other parts of the body such as the torso and abdomen, which are relatively well-protected by body armor, since Warfighters must expose their heads from behind cover to engage an enemy (Ari, 2006; Thomas et al., 2009; Weichel et al., 2008). This action subjects their eyes to possible blast and/or projectile injuries, especially when they do not wear ocular personal protective equipment (PPE) (Thomas et al., 2009). The blast impact or projectile force on the eye is concentrated over a very small surface area, compared to a similar force impact on other parts of the body. This concentrated force is particularly injurious to the eye (Thomas et al., 2009; Wong and Seet, 1997).

A retrospective OBI analysis is now timely, since Operation Iraqi Freedom (OIF) / Operation New Dawn (OND) ended in 2011, while Operation Enduring Freedom (OEF), begun in 2001, is still ongoing (Burns, 2012; Torreon, 2011). Evaluating the effectiveness of ocular PPE used during these conflicts will help to improve ocular PPE use in future conflicts. Therefore, in conjunction with the U.S. Army Institute of Surgical Research (USAISR), the U.S. Army Aeromedical Research Laboratory (USAARL), Visual Sciences Branch (VSB) is conducting research into Warfighter PPE improvement to support the U.S. Army Medical Research and Materiel Command's (USAMRMC) Military Operational Medicine Research Program, Task Area A2: "Protect the Warrior from ocular and facial injury." In response to the VSB chief's request for information (RFI) submitted to the Joint Trauma Analysis and Prevention of Injury in Combat (JTAPIC) program, USAARL's Operational Survival Analysis Section (OSAS) studied OBI among U.S. military personnel as a starting point for this research. Upon review of the RFI, which outlined the data analyses requested, USAMRMC's Human Research Protection Office (HRPO) determined this study did not involve a human research activity, and therefore, no further HRPO review[1] or Institutional Review Board (IRB) review was needed (S. Donahue, personal communication, September 1, 2011).

This technical report describes the OBI study and reflects content presented in a poster (appendix A) at the Fifth Military Vision Symposium on Ocular and Vision Injury in Boston, Massachusetts, September 2012. The data of annually deployed personnel for each military operation reported by the Office of the Secretary of Defense are summarized in appendix B. Additional content not presented in the poster is included in appendix C. The study objectives were to: (1) describe OBI incidence among U.S. military personnel during OEF, OIF, and OND, (2) describe OBI mechanisms, severity, type, and diagnoses, and (3) describe other head injuries co-occurring with OBI. Finally, this report discusses the study findings, limitations, conclusions, and recommendations.

[1] HRPO reviewed and approved a separate study protocol that one of the study coauthors (José E. Capó-Aponte) submitted for a related research project.

Methods

Table 1 outlines the study scope. We obtained OBI data from the Joint Theater Trauma Registry (JTTR), a repository of all Department of Defense (DOD) trauma patient data collected by the Joint Trauma System, USAISR, a JTAPIC program partner. In response to the VSB chief's RFI, USAISR data analysts abstracted and sent to the study authors de-identified JTTR records of U.S. military personnel treated for OBI at a level 3 (combat surgical hospital, Air Force theater hospital, or expeditionary medical facility) and higher military medical treatment facility from March 2002 through December 2011. The study authors analyzed the data at both the individual case level and injury level, and reported the frequencies and percentages of variable values describing OBI incidence, mechanisms, severity, type, diagnoses, and other head injuries co-occurring with OBI.

Table 1.
Scope.

Parameter	Description
Study design	Retrospective cross-sectional study of individual and injury level data.
Population	U.S. military personnel with OBI.
Dates	March 2002 through December 2011.
Data sources	JTTR, Joint Trauma System, USAISR (OBI data); Office of the Secretary of Defense (deployed personnel data).
Distribution	OEF, OIF, and OND.
Inclusion criteria	OBI patients receiving level 3 (combat surgical hospital, Air Force Theater hospital, or expeditionary medical facility) and higher care.

To calculate annual OBI case rates, the study authors obtained annual deployed personnel data for each military operation as of 30 June each year (Office of the Secretary of Defense, 2012). OIF deployed personnel data are available since 2003, while OEF deployed personnel data are available since 2005. For each military operation, annual OBI cases were divided by annual deployed personnel numbers and multiplied by 100,000 to calculate annual OBI case rates per 100,000 deployed personnel.

We calculated OBI severity using an eye injury scale of 1 (*least severe*) to 4 (*most severe*) (table 2) based on International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) eye injury diagnosis codes. Ocular researchers graded each eye injury diagnosis code's severity level based on the need for eye surgery and/or potential for vision loss each eye injury can cause (Duma et al., 2002; Thomas et al., 2009). We chose to use this eye injury scale because it is more informative for grading eye injury severity than the Abbreviated Injury Scale (AIS), which grades eye injuries on a scale of 1 (*minor*) to 3 (*serious*), based on their overall threat to life (Duma et al., 2002; Trauma.org, 1995). Because eye injuries are usually not life-threatening, they are assigned low AIS scores of 1 (*minor*) or 2 (*moderate*) (Gennarelli and Wodzin, 2005), no matter how serious the eye injury is. Thus, the AIS is less informative for grading eye injury severity than the 4-level scale we chose to use. If an OBI patient sustained more than one eye injury, only the most severe eye injury was included in the individual level data analysis.

Table 2.
Eye injury severity.

Severity level	Description	ICD-9-CM code	Description
1	*Least severe*	870.2	Laceration of eyelid involving lacrimal passages
		921.1	Periocular contusion
2	*Less severe*	918.1	Superficial corneal injury
		918.9	Superficial eye injury
3	*More severe*	871.0	Ocular laceration without prolapse
		871.4	Laceration of the eye, unspecified
		871.7	Ocular penetration, unspecified
		921.3	Eyeball contusion
		940.4	Other corneal / conjunctival burn
4	*Most severe*	871.2	Eye rupture with tissue loss
		871.3	Eye avulsion
		950.0	Optic nerve injury

Results

OBI individual cases

This study included 1732 total OBI individual cases. Figure 1 breaks out these cases by military operation. Approximately 69 percent occurred during OIF and OND, and 31 percent occurred during OEF.

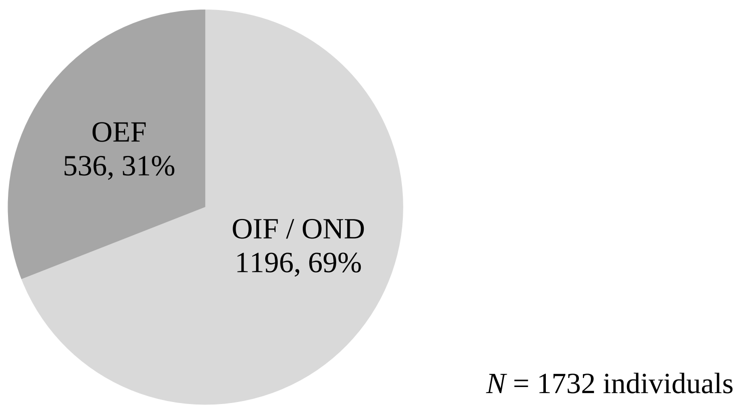

Figure 1. OBI cases by military operation.

Figure 2 breaks out OBI individual cases by calendar year for OIF / OND. These cases decreased 95 percent from 2004 to 2010, coinciding with a 58 percent reduction in deployed personnel.

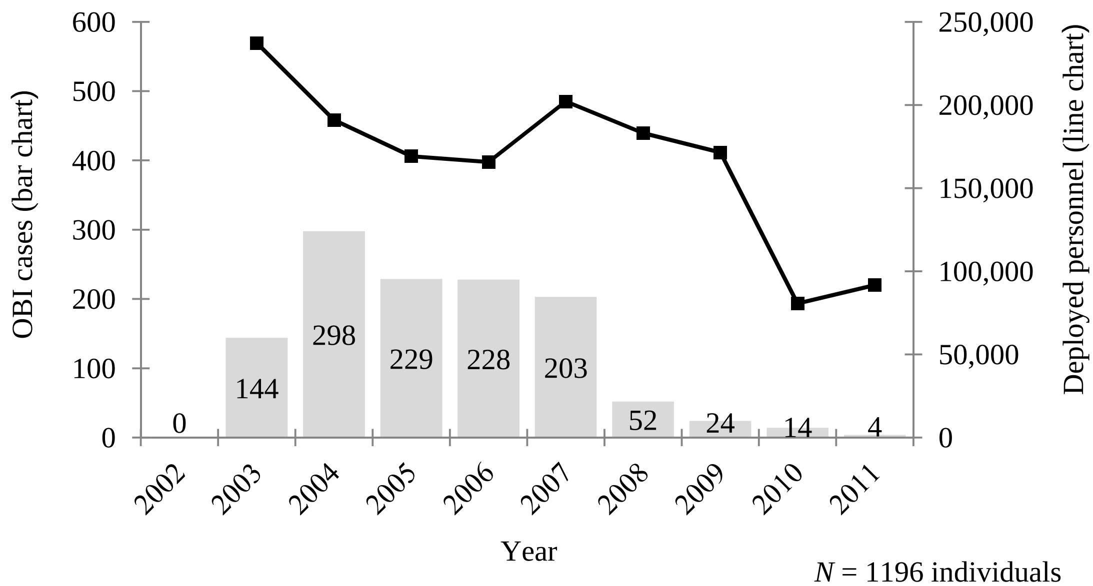

Figure 2. OBI cases and deployed personnel by calendar year (OIF / OND).

Figure 3 breaks out OBI individual cases by calendar year for OEF. These cases rose 284 percent from 2008 to 2010, coinciding with a 202 percent increase in deployed personnel.

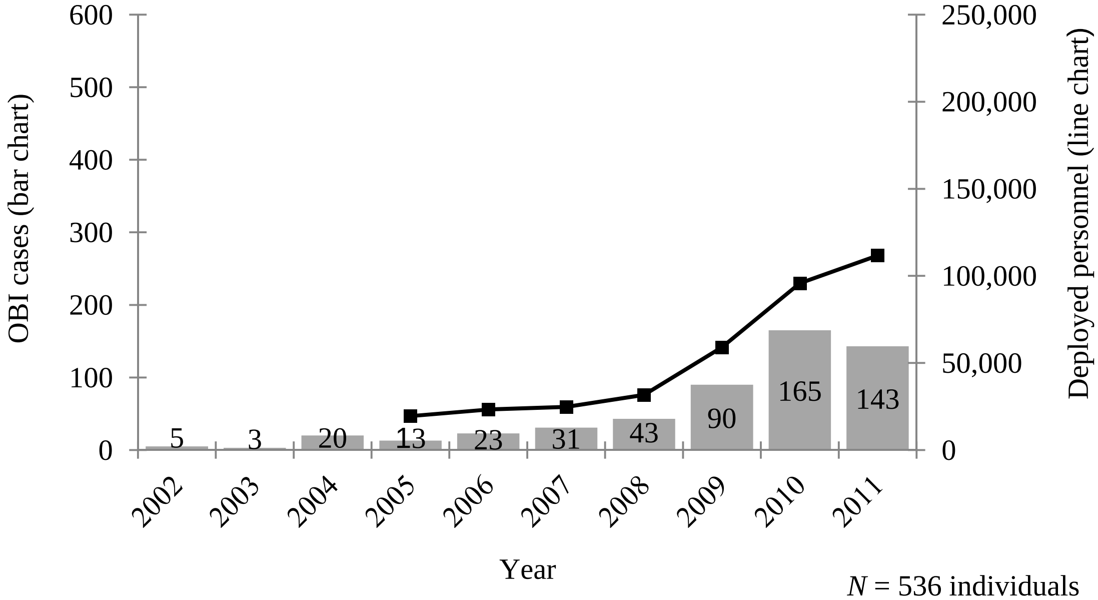

Figure 3. OBI cases and deployed personnel by calendar year (OEF).

Figure 4 breaks out OBI individual cases by service. Soldiers made up 72 percent of cases, followed by Marines (24 percent).

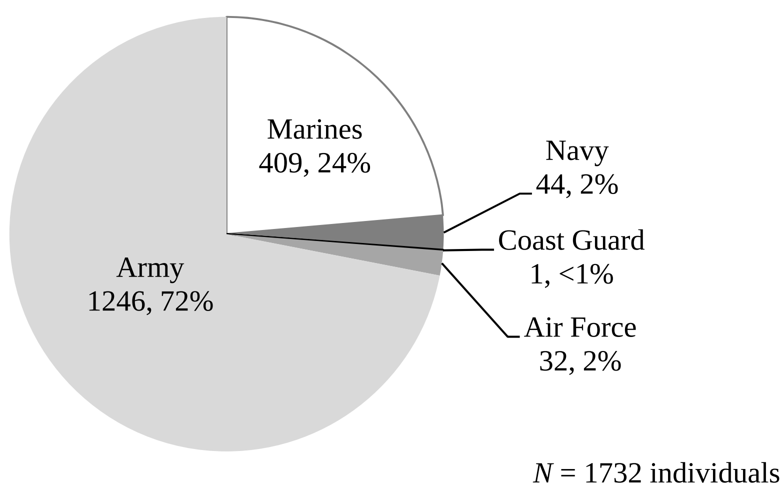

Figure 4. OBI cases by service.

OBI mechanisms, severity, type, and diagnoses

Figure 5 breaks out OBI individual cases by event mechanism (injury cause). Blasts from explosives caused 92 percent of cases.

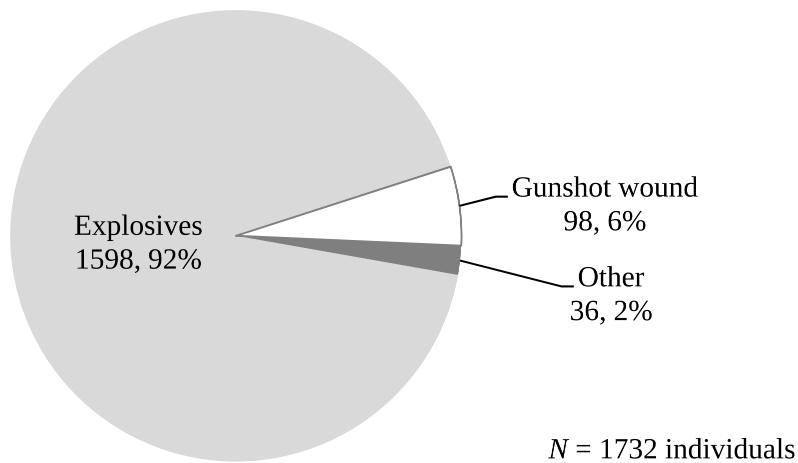

Figure 5. OBI cases by event mechanism.

Figure 6 breaks out OBI individual cases by injury severity. Approximately 63 percent of cases had a severity level of 3 (*more severe*) or 4 (*most severe*).

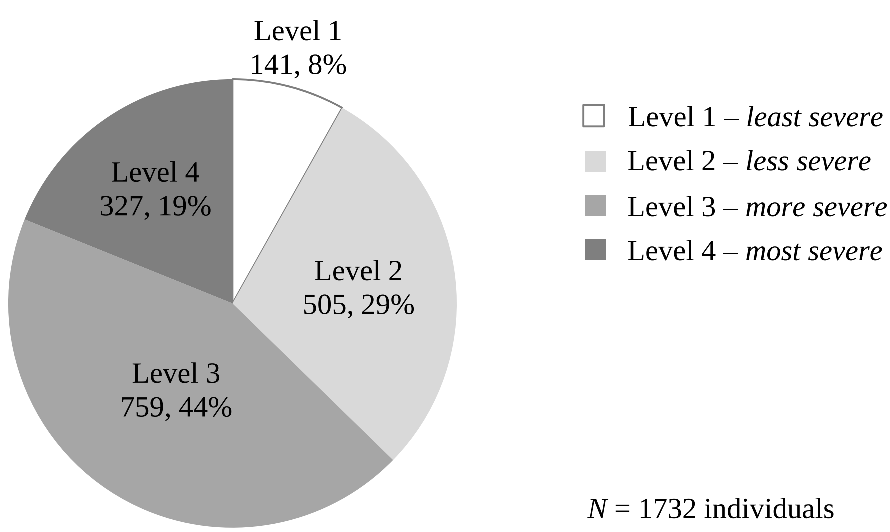

Figure 6. OBI cases by injury severity.

Figure 7 breaks out OBI at the injury level by injury type, severity, and ICD-9-CM code. Fifty percent (1611 of 3222) of all OBI were open wounds, and 86 percent (314 of 365) of OBI with the highest injury severity 4 (*most severe*), were also open wounds.

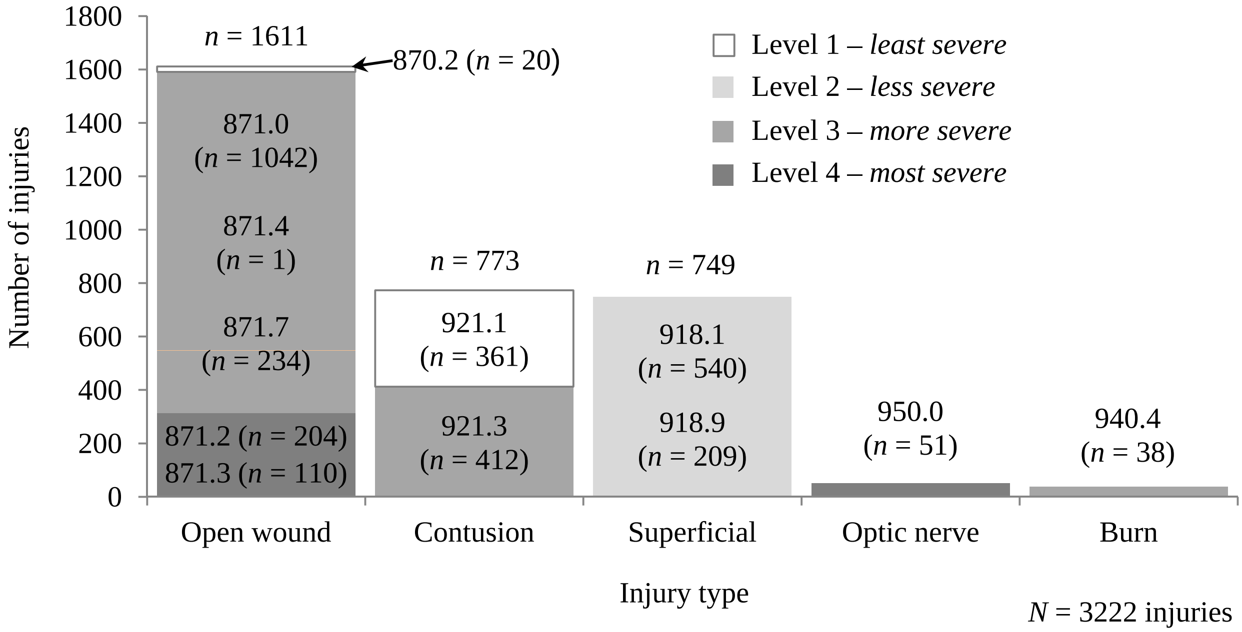

Figure 7. OBI cases by injury type, severity, and ICD-9-CM code.

Other head injuries co-occurring with OBI

Figure 8 shows the overlap of OBI individual cases with other head injury individual cases. Overall, 84 percent of OBI cases had one or more other head injury type(s) (1452 out of 1732 individuals). Approximately 71 percent of OBI cases had another facial injury (1230 out of 1732 individuals), 48 percent had a traumatic brain injury (TBI) (832 out of 1732 individuals), and 25 percent had an acoustic injury (427 out of 1732 individuals).

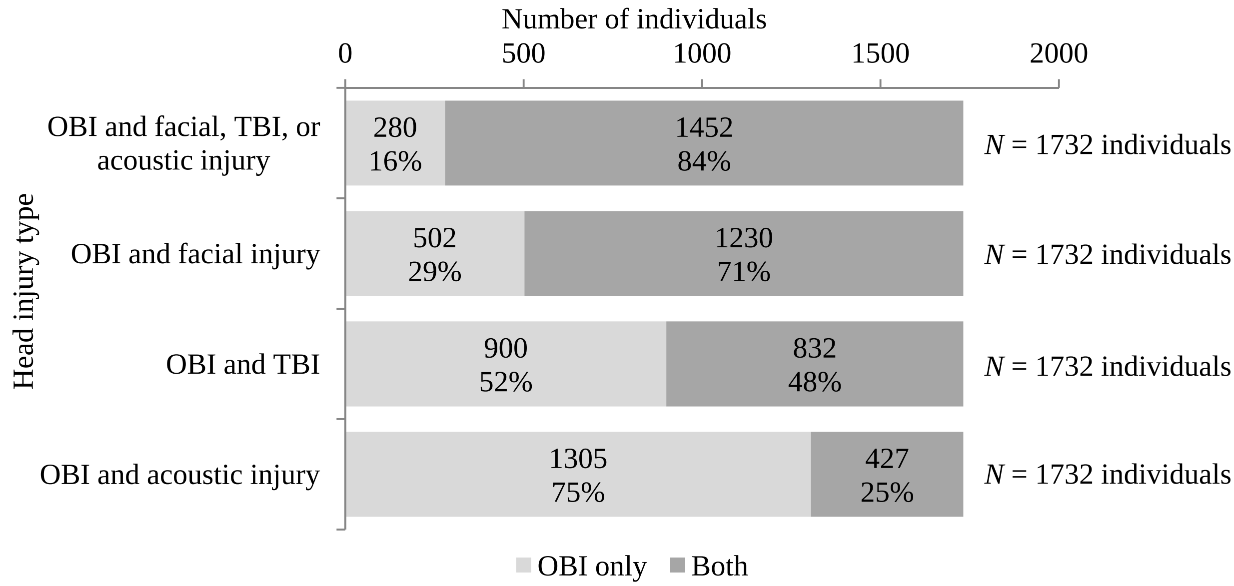

Figure 8. OBI cases and other head injury cases.

Discussion

The results show OBI individual cases mirrored deployed personnel numbers: the greater the number of deployed personnel, the higher the OBI incidence. OBI cases were higher in OIF / OND (figure 2) than in OEF (figure 3), and higher among Soldiers and Marines than in other Armed Services (figure 4), due to the greater number of deployed personnel in OIF / OND and from the Army and Marine Corps to support these operations (figures B1 and B2). Both annual OBI cases (figures 2 and 3) and annual OBI incidence rates per 100,000 deployed personnel (figure C1) rose or fell as annual deployed personnel numbers rose or fell.

The results also show OBI severity was associated with eye injury type (figure 7), and hence the need for eye surgery and/or potential for vision loss. Eyelid injuries (lacerations and contusions) were assigned severity level 1 (*least severe*). These were the least severe injuries with less need for eye surgery, and the lowest potential for vision loss. Superficial cornea injuries and other superficial eye injuries were assigned severity level 2 (*less severe*). These were more severe than eyelid injuries, with some potential for vision loss. Eye lacerations, eye penetrations, eyeball contusions, and cornea burns were assigned severity level 3 (*more severe*). These were even more severe injuries, since they require eye surgery. Eye ruptures, eye avulsions, and optic nerve injuries were assigned severity level 4 (*most severe*). These were the most severe injuries, since they resulted in vision loss. Half of all OBIs were open wounds, and of these, 99 percent were assigned severity levels 3 (*more severe*) or 4 (*most severe*).

Over 90 percent of total OBI cases resulted from explosive blasts (figure 5), the most common injury cause in OIF / OND, and OEF. Not surprisingly, 84 percent of OBI cases had another head injury type (facial, TBI, or acoustic injury), in particular facial injury (71 percent of OBI cases) (figure 8). Of the 832 OBI cases sustaining a TBI, 16 percent sustained a type 1 (most severe) TBI, 84 percent sustained a type 2 (less severe) TBI, and less than 1 percent sustained a type 3 (least severe) TBI[2] (figure C2). Of the 427 OBI cases sustaining an acoustic injury, 95 percent sustained a ruptured eardrum (figure C3). Thus, the typical OBI patient was complex, sustaining multiple traumatic head injuries, most often from explosive blasts.

Limitations

This study was limited by the following:

a. No data on ocular PPE use were available at the time of this study. This hampered our ability to evaluate ocular PPE use compliance and effectiveness to mitigate or prevent OBI. However, the mean eye injury severity of mounted casualties was lower than that of dismounted casualties in almost any given year, and generally showed an annual downward trend (figure C4). This mitigation might be attributable to increased ocular PPE use (Hilber, 2011; Thomas et al., 2009) and/or Mine Resistant Ambush Protected (MRAP) vehicles fielded in theater during this study's time frame (Lamb and Scudder, 2012). When available, ocular PPE use data may enable a more definitive analysis of its effectiveness to mitigate or prevent OBI.

b. Exposure data were limited to the injury cause, such as explosives or gunshot wound, in the JTTR data base. When available, information such as net explosive weight and distance from explosive blast may enable the modeling of a dose-response relationship between blast exposure and OBI severity.

c. Because the JTTR data base is dynamic and is retroactively updated as new records or information become available, the 2011 data available at the time of this study may be underreported due to a reporting lag. This may explain the apparent decrease in OBI cases in OEF from 2010 to 2011, despite an increase in OEF deployed personnel from 2010 to 2011 (figure 3), and an increase in the percentage of blast-injured OBI cases in OEF from 2010 to 2011 (figure C5).

Conclusions

As a result of this retrospective study of OBI incidence among U.S. military personnel, we make the following conclusions:

a. OBI case numbers and case rates increase or decrease proportionally as deployed personnel numbers increase or decrease in proportion to threat levels and injury risk.

[2] According to Barell et al. (2002), TBI types are classified as follows: type 1 TBI is defined as an intracranial injury, a head injury with moderate or prolonged loss of consciousness, or an optic nerve injury, type 2 TBI is defined as a head injury with loss of consciousness of less than 1 hour or of an unknown or unspecified duration, with no evidence of intracranial injury, and type 3 TBI is defined as a head injury with no loss of consciousness or evidence of intracranial injury.

b. The high co-occurrence of OBI with other head injury types results from the predominance of explosive blasts (92 percent) as an OBI cause, resulting in the constellation of co-occurring ocular, acoustic, facial, and brain injuries seen.

c. Increased ocular PPE use and MRAP vehicle deployment may mitigate eye injury severity of mounted casualties.

d. Further analysis is needed to model the relationship between blast exposure, OBI severity, and the mitigating effect of ocular PPE use by linking together and analyzing data sets containing exposure, eye injury, and ocular PPE use information.

Recommendations

Based on the study results and conclusions above, we make the following recommendations to increase combat ocular readiness in future conflicts:

a. Medical planners should participate in military operational planning and decision making to maintain situational awareness for allocating medical resources commensurate with threat levels and injury risk to deployed personnel (Davis and Bricknell, 2012).

b. Health care providers should evaluate and treat blast-injured OBI patients with a high index of suspicion for other occult head injuries, in particular, closed-eye ocular injuries and TBI (Cockerham et al., 2011).

c. Military leaders should leverage findings of combat ocular injury studies, such as this one, to support their enforcement of mandatory ocular PPE use in accordance with Department of the Army (DA) Pamphlet 40-506 (Department of the Army, 2009).

d. Military units such as Program Executive Office (PEO) Soldier and USAISR should collect and make available exposure and ocular PPE use data. These data may be linked to JTTR records to enable military medical researchers to model the relationship between blast exposure, OBI severity, and ocular PPE use.

References

Ari, A. B. 2006. Eye injuries on the battlefields of Iraq and Afghanistan: Public health implications. Journal of the American Optometric Association. 77: 329-339.

Barell, V., Aharonson-Daniel, L., Fingerhut, L. A., Mackenzie, E. J., Ziv, A., Boyko, V., Abargel, A., Avitzour, M., and Heruti, R. 2002. An introduction to the Barell body region by nature of injury diagnosis matrix. Injury prevention. 8: 91-96.

Burns, R. 2012. New Afghan war phase, with no decisive end seen. Retrieved from http://www.stripes.com/news/middle-east/afghanistan/new-afghan-war-phase-with-no-decisive-end-seen-1.194799.

Cockerham, G. C., Rice, T. A., Hewes, E. H., Cockerham, K. P., Lemke, S., Wang, G., Lin, R. C., Glynn-Milley, C., and Zumhagen, L. 2011. Closed-eye ocular injuries in the Iraq and Afghanistan wars. The New England journal of medicine. 364: 2172-2173.

Davis, S. L., and Bricknell, M. 2012. Developing an operational casualty estimate in a multinational headquarters to inform and drive medical resource allocation. The United States Army Medical Department journal. (October-December) 51-57.

Department of the Army. 2009. The Army vision conservation and readiness program. Washington, DC: Department of the Army. DA Pamphlet 40-506.

Duma, S. M., Jernigan, M. V., Stitzel, J. D., Herring, I. P., Crowley, J. S., Brozoski, F. T., and Bass, C. R. 2002. The effect of frontal air bags on eye injury patterns in automobile crashes. Archives of ophthalmology. 120: 1517-1522.

Gennarelli, T. A., and Wodzin, E., eds. 2005. Abbreviated Injury Scale 2005. Barrington, IL: Association for the Advancement of Automotive Medicine.

Hilber, D. J. 2011. Eye injuries, active component, U.S. armed forces, 2000-2010. Medical surveillance monthly report. 18: 2-7.

Lamb, C. J., and Scudder, S. 2012. Why the MRAP is worth the money. Retrieved from http://www.foreignaffairs.com/articles/138049/christopher-j-lamb-and-sally-scudder/why-the-mrap-is-worth-the-money.

National Alliance for Eye and Vision Research. 2007. National Alliance for Eye and Vision Research (NAEVR) request to maintain “eye and vision research” eligibility in the peer reviewed medical research program in fiscal year (FY) 2008 DOD appropriations. Retrieved from http://www.eyeresearch.org/naevr_action/cdmrp08.html.

Office of the Secretary of Defense. 2012. Military personnel statistics. Retrieved from http://siadapp.dmdc.osd.mil/personnel/MILITARY/miltop.htm.

Thomas, R., McManus, J. G., Johnson, A., Mayer, P., Wade, C., and Holcomb, J. B. 2009. Ocular injury reduction from ocular protection use in current combat operations. The journal of trauma injury, infection, and critical care. 66: S99-S103.

Torreon, B. S. 2011. U.S. periods of war and dates of current conflicts. Washington, DC: Congressional Research Service. CRS Report RS21405.

Trauma.org. 1995. Abbreviated Injury Scale. Retrieved from http://www.trauma.org/archive/scores/ais.html.

Weichel, E. D., Colyer, M. H., Ludlow, S. E., Bower, K. S., and Eisman, A. S. 2008. Combat ocular trauma visual outcomes during operations Iraqi and Enduring Freedom. Ophthalmology. 115: 2235-2245.

Wong, T. Y., and Seet, B. 1997. A behavioral analysis of eye protection use by soldiers. Military medicine. 162: 744-748.

Ocular Battle Injuries Among U.S. Military Personnel, 2002-2011

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Purpose

This poster describes the incidence of ocular battle injuries (OBI) among U.S. military personnel to inform researchers into the effectiveness of ocular personal protective equipment (PPE).

Methods

Table 1. Scope.

Parameter	Description
Study design	Cross-sectional study of individual and injury level data. Eye injury severity was calculated on a scale of one to four[1] (table 2).
Population	U.S. military personnel with OBI.
Dates	March 2002 through December 2011.
Data sources	Joint Theater Trauma Registry, Joint Trauma System/United States Army Institute of Surgical Research (OBI); Office of the Secretary of Defense (deployed personnel).
Distribution	Operation Enduring Freedom (OEF), Operation Iraqi Freedom (OIF), and Operation New Dawn (OND).
Inclusion criteria	OBI patients receiving level 3 care (combat surgical hospital, Air Force theater hospital, or expeditionary medical facility) and higher.

Table 2. Eye injury severity.

Severity level	Description	International Classification of Diseases-9 (ICD-9) codes
[1]	Skin, eyelid, or orbit area soft tissue	870.2 (eyelid laceration) 921.1 (eyelid contusion)
[2]	Eye, less severe	918.1 (superficial injury of cornea), 918.9 (other superficial eye injury)
[3]	Eye, more severe	871.0, 871.4 (eye laceration) 871.7 (eye penetration) 921.3 (eyeball contusion) 940.4 (burn of cornea)
[4]	Eye, most severe	871.2 (eye rupture) 871.3 (eye avulsion) 950.0 (optic nerve injury)

Results

Figure 1. OBI cases by military operation.

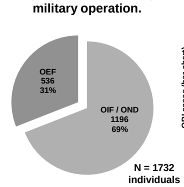


Figure 2. OBI cases and deployed personnel by calendar year (OIF / OND).

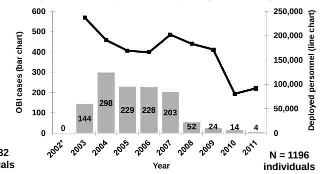


Figure 3. OBI cases and deployed personnel by calendar year (OEF).

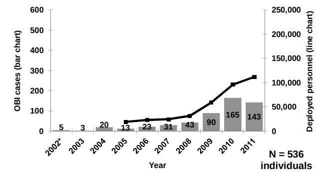


Figure 4. OBI cases by service.

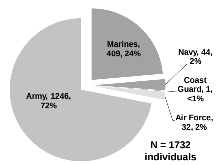


Figure 5. OBI cases by event mechanism.

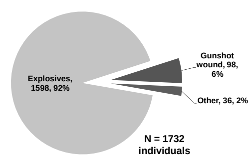


Figure 6. OBI cases by injury severity.

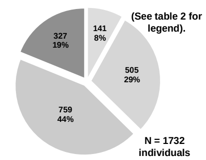


Figure 7. OBI by injury type, severity, and ICD-9 code.

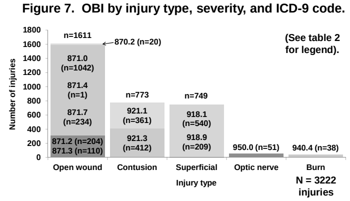
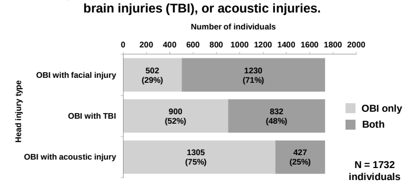


Figure 8. OBI cases with facial injuries, traumatic brain injuries (TBI), or acoustic injuries.



Discussion

Individual OBI cases in OIF / OND declined 95 percent from 2004 to 2010, coinciding with a 58 percent reduction in deployed personnel[2] (figure 2). Increased ocular PPE use[3] and fielding of Mine Resistant Ambush Protected (MRAP) vehicles[4] during this period may also have contributed to this decline. OBI cases in OEF rose 284 percent from 2008 to 2010, coinciding with a 202 percent increase in deployed personnel[2] (figure 3). Ninety-two percent of OBI cases were injured by blasts from explosives (figure 5). Fifty percent (1611 of 3222) of all OBI were open wounds, and 86 percent (314 of 365) of OBI with the highest injury severity [4] were also open wounds (figure 7). Seventy-one percent of OBI cases also sustained another facial injury (figure 8).

Limitation

- No data on ocular PPE use were available at the time of this study.

Conclusions

- Blast exposure was the predominant cause of OBI among U.S. military personnel.
- When available, data on ocular PPE use will enable analysis of its effectiveness to mitigate or prevent OBI.

Recommendations

- Require enforcement of mandatory ocular PPE use in accordance with Department of the Army Pamphlet 40-506[5].
- Collect ocular PPE use data to assess PPE effectiveness.

References

1. Duma, S. M., Jernigan, M. V., Stitzel, J. D., Herring, I. P., Crowley, J. S., Brozoski, F. T., and Bass, C. R. 2002. The effect of frontal air bags on eye injury patterns in automobile crashes. Archives of ophthalmology. 120: 1517-1522.
2. Office of the Secretary of Defense. 2012. Military personnel statistics. Retrieved from http://siadapp.dmdc.osd.mil/personnel/MILITARY/miltop.htm.
3. Hilber, D. J. 2011. Eye injuries, active component, U.S. armed forces, 2000-2010. Medical surveillance monthly report. 18: 2-7.
4. Lamb, C. J., and Scudder, S. 2012. Why the MRAP is worth the money. Retrieved from http://www.foreignaffairs.com.
5. Department of the Army. 2009. The Army vision conservation and readiness program. Washington, DC: Department of the Army. DA Pamphlet 40-506.

Appendix B.

Deployed personnel by military operation, service, and calendar year.

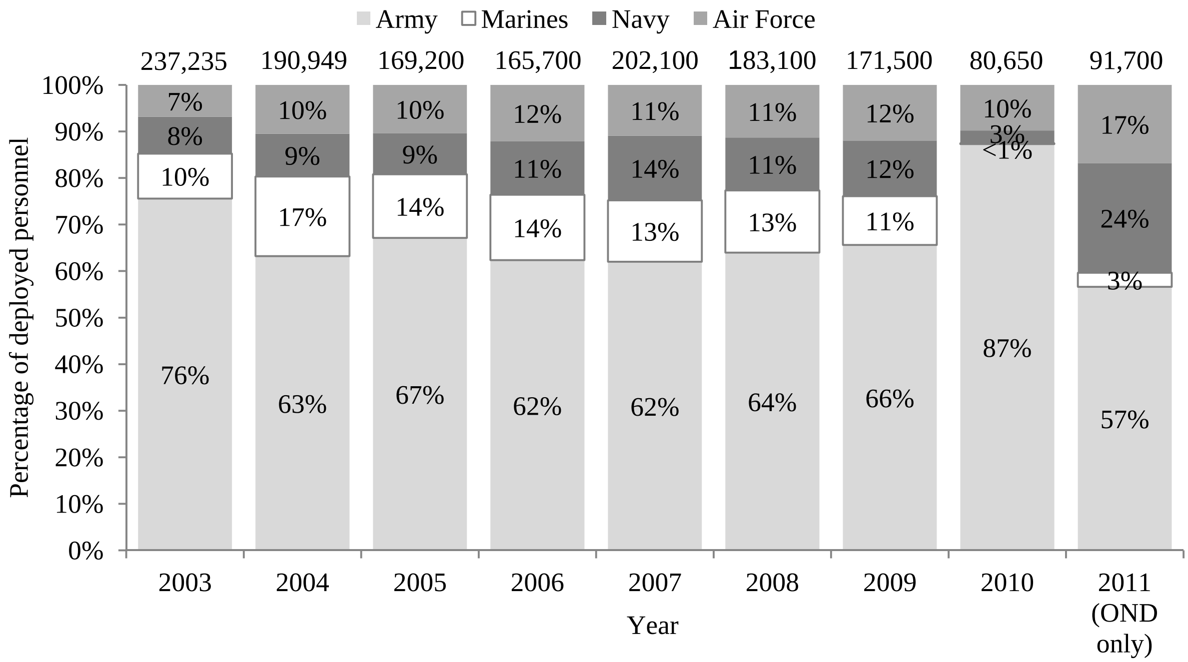


Figure B1. Deployed personnel by service and calendar year as of 30 June (OIF / OND).

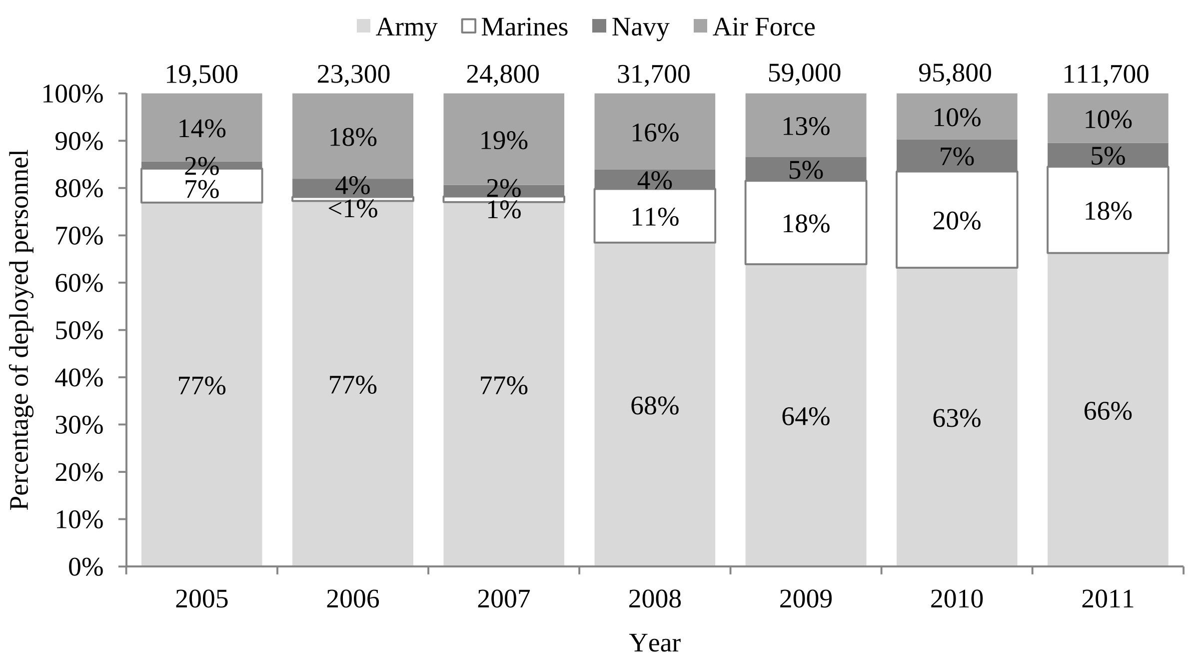


Figure B2. Deployed personnel by service and calendar year as of 30 June (OEF).

Appendix C.

Additional analyses.

Figure C1 shows OBI case rates per 100,000 deployed personnel for OIF / OND, and OEF by calendar year. The rate for OIF / OND deployed personnel was highest in 2004 (156.1 per 100,000) and the rate for OEF deployed personnel was highest in 2010 (172.2 per 100,000).

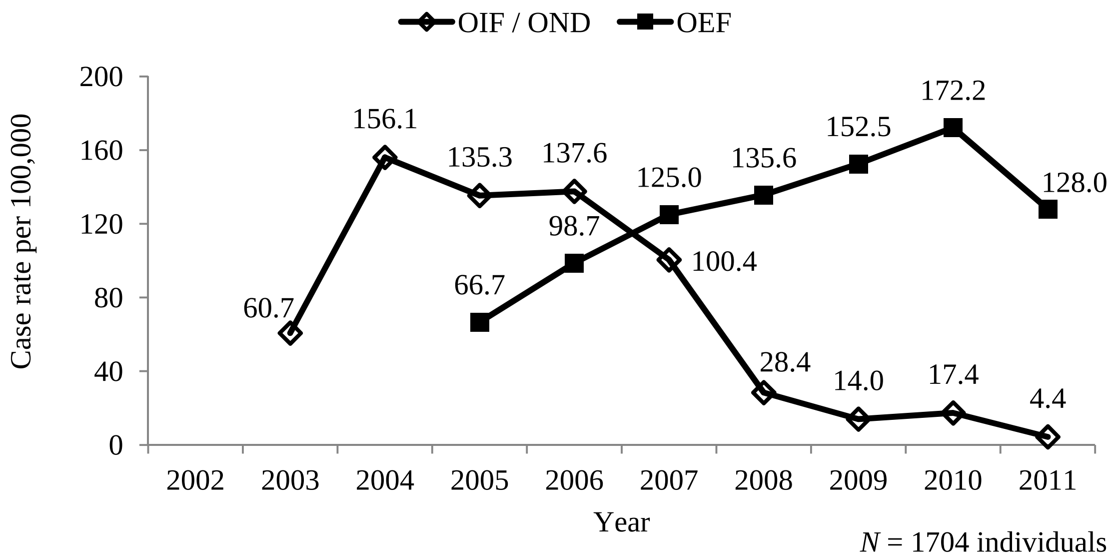


Figure C1. OBI case rates per 100,000 deployed personnel by military operation and calendar year.

Figure C2 shows OBI cases with TBI by TBI type. According to Barell et al. (2002), TBI types are classified as follows: type 1 (most severe) TBI is defined as an intracranial injury, a head injury with moderate or prolonged loss of consciousness, or an optic nerve injury, type 2 (less severe) TBI is defined as a head injury with loss of consciousness of less than 1 hour or of an unknown or unspecified duration, with no evidence of intracranial injury, and type 3 (least severe) TBI is defined as a head injury with no loss of consciousness or evidence of intracranial injury.

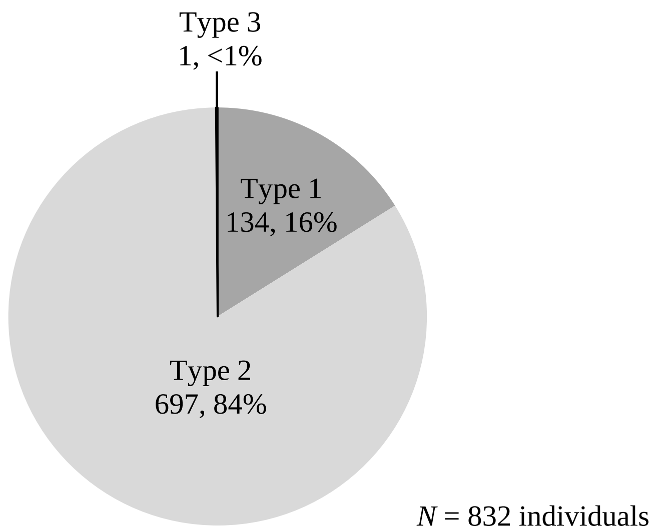


Figure C2. OBI cases with TBI by TBI type.

Figure C3 shows OBI cases with acoustic injuries by acoustic injury type. Of 427 individual OBI cases sustaining an acoustic injury, 95 percent sustained a ruptured eardrum.

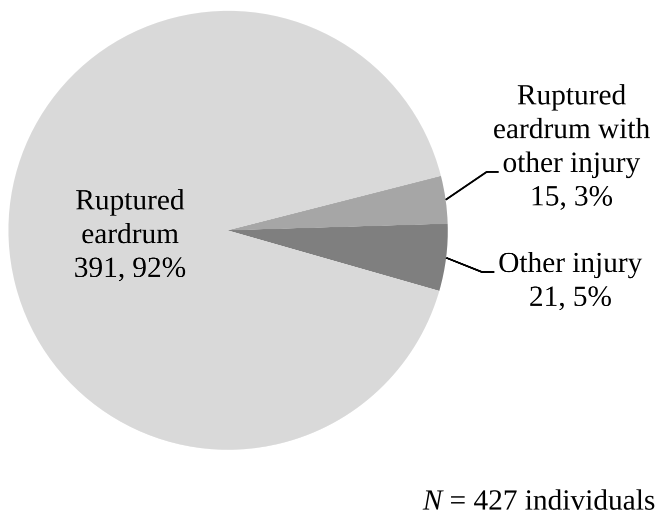


Figure C3. OBI cases with acoustic injuries by acoustic injury type.

Figure C4 shows the mean eye injury severity of mounted and dismounted casualties by calendar year. Mean eye injury severity of mounted casualties was lower than that of dismounted casualties in every year except 2003. Mean eye injury severity of mounted casualties also showed a general downward trend in every year except 2010.

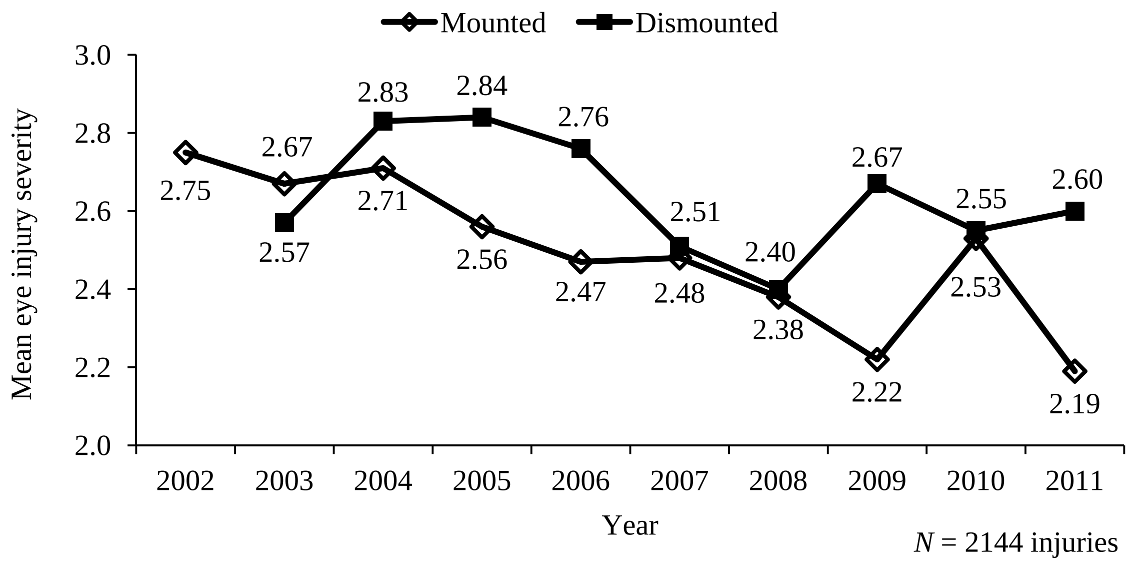


Figure C4. Mean eye injury severity by mounted status and calendar year.

Figure C5 shows the percentage of blast-injured OBI cases for OIF / OND, and OEF by calendar year, which remained high and relatively constant throughout this study's time frame.

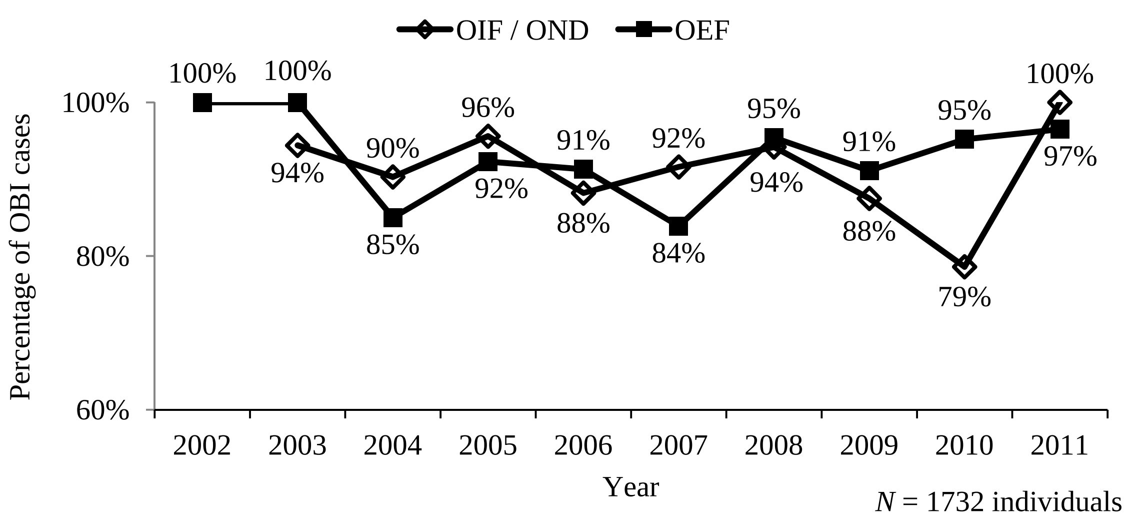


Figure C5. Percentage of blast-injured OBI cases by military operation and calendar year.

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